SB761
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#81-22

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UNITED STATES
SPRUCE BUDWORMS
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U.S.D.A. Forest Service
Missoula, Montana 59807

A MULTIPLE GROUND APPLICATION OF ACEPHATE AND CARBARYL FOR PROTECTION OF DOUGLAS-FIR CONES FROM WESTERN SPRUCE BUDWORM

Report 81-22

December 1981

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Title

A Multiple Ground Application of Acephate and Carbaryl for Protection of Douglas-fir Cones from Western Spruce Budworm

By

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Abstract

A multiple ground application of acephate and carbaryl for protection of Douglas-fir cones and seeds from the western spruce budworm was conducted at Lubrecht Experimental Forest, Montana, during 1980. A total of 70 cone bearing trees were selected and randomly assigned to 1 of 7 treatments (10 single tree replications of 2 double, 4 triple and 1 control). Timing of the first application was scheduled when expanding cone buds were still erect and about an inch long (May 8-12). The acephate and carbaryl were mixed and applied according to label instructions and were applied by hydraulic pumper with a handgun. Foliage protection for 1980 averaged 97 percent. No treatment differences were found for seed condition (sound, hollow, or damaged) or seed germination (percent). There were no significant seed yield differences between double and triple treatments but all double and triple treatments were significantly different from the control.

A double application of acephate or carbaryl is recommended for improved seed yield in areas of moderate to heavy budworm populations.

Introduction

To meet the reforestation and stand improvement goals established by the 1976 National Forest Management Act, the Northern Region (R-1) of the USDA-Forest Service set Douglas-fir seed requirements at approximately 230 pounds per year for the next 5 years. To fill seed zone seedling needs, seed collections must come from a wide range of habitat types and elevational zones within the major seed zones in R-1. Although limited seed exchange between habitat types is permitted, shortages have occurred and are predicted to reoccur especially in high elevation Douglas-fir stands. At present, seed collections are largely dependent on bumper crop years. In between, little or no seed is collected. When western spruce budworm outbreaks persist in shortage areas, planting stock inventories can become critically low.

In 1979, R-1 evaluated a ground application of acephate and carbaryl designed to test foliage and cone protection. These results were encouraging but identified two problems. First, prior to the May 21, 1979 application, approximately 30 percent of the cones were lost due to budworm damage. Second, even though budworm population reduction was high (83 to 94 percent), residual protection was too short to prevent late season damage by budworm and other cone and seed insects. Only a small increase in seed yield was recorded.

To resolve these problems this multiple application project was designed using both acephate and carbaryl. Double and triple applications were used to extend the period of insecticide effectiveness. An earlier timing of the first application was used to reduce prespray cone loss.

Objective

The objective of this project was to evaluate the effectiveness of an early double and triple application of acephate and carbaryl to protect Douglas-fir cones against the western spruce budworm and other seed and cone insects.

Project Area

This project was conducted in an open-grown Douglas-fir stand located near Coyote Park on Lubrecht Experimental Forest which is administered by the University of Montana, Missoula, Montana. This site located 25 miles northeast of Missoula had a good combination of trees with, (1) a large number of reproductive buds, (2) suitable tree condition and size, and (3) moderate to heavy budworm population.

Administration and Funding

Personnel from Forest Pest Management (FPM), State and Private Forestry, Northern Region, administered this project. Overall coordination and supervision was the responsibility of the Canada/U.S. (CANUSA) spruce budworm specialist assigned to FPM. The FPM laboratory personnel and facilities were used to process larval, cone, seed and defoliation samples. X-ray equipment located at the Forestry Sciences Laboratory, University of Montana, was used for seed examination. Funding was provided through the budget allotment to FPM from the CANUSA program.

Insecticides

Acephate (Orthene® Forest Spray: O,S-Dimethylacetylophosphoramidothioate) is an organophosphate insecticide of moderate persistence and is primarily a contact and stomach poison with limited residual systemic action. The water soluble formulation is 57 percent active

ingredient (A.I.) by weight. Carbaryl (Sevimol® 4: 1-naphthylmethylcarbamate) is a widely used forest and agricultural material of moderate persistence. Sevimol 4 is a molasses formulation of carbaryl at 4 pounds A.I. per gallon.

Timing and Application

Timing of the first application was scheduled when most of the seed cone buds had expanded and were fully open. On May 2, 1980, only seven of the 50 sample trees did not meet these conditions. Subsequent applications were to follow at 14-day intervals. Our plans to apply the first application on May 5, 1981, were delayed by other commitments of the spray equipment. The first applications were not applied until May 8 and 9 per the following schedule:

Date	Treatment (Applications)
May 8	Acephate (2) and Carbaryl (2)
May 9	Acephate (3) and Carbaryl (3)

On May 9, as we neared completion of the day's spraying a light rain began. Rain showers occurred off and on for the rest of the day. Precipitation for this period was recorded as follows:

Date	Precipitation (inches)
May 8	0
May 9	.71
May 10	0
May 11	1.03
May 12	0
May 13	0
May 14	.73
May 15	0

Since both triple applications had little or no initial drying time and a fair amount of rain, we decided to select an additional set of sample trees and redo both triple applications. Prespray samples were collected and additional treatments were made on May 12, 1981.

Further changes were made following a heavy dusting of volcanic ash caused by the eruption of Mount St. Helens on May 18, 1980, and the heavy rains which followed (3.83 inches in 3 days). The scheduled first postspray sample and second application were delayed until May 27 and 28 and May 30 respectively. The remaining applications and sampling proceeded on schedule:

Second postspray	June 9
Third application	June 16
Third postspray	June 30

Both insecticides were applied during early morning hours using a hydraulic pumper operated at 400 pounds per square inch. Between treatments spray equipment was cleaned with Nutra-Sol® and rinsed with water. The following tank mixes were prepared in 200-gallon batches:

Acephate: 2/3 lb. (1/2 lb A.I.) in 100 gallons water

Carbaryl: 2 qt. (2 lbs A.I.) in 100 gallons water

These mixtures were applied to just beyond the point of runoff (5 to 6 gallons per tree). Normal insecticide safety precautions were observed during storage, handling, mixing, and application.

Design and Sampling

Ten single tree replications were used for each of seven treatments. Originally five treatments were proposed then two additional trials were added when two of the first set were rained on. Approximately 90 trees were selected from which 50 were randomly assigned to one of the following treatments:

Treatment	Material	Applications
1 (A2)	Acephate	2
2 (A3)	Acephate	3
3 (C2)	Carbaryl	2
4 (C3)	Carbaryl	3
5 (k)	Control	None

An additional 20 trees were selected and assigned the following treatments.

6 (A3R)	Acephate	3
7 (C3R)	Carbaryl	3

Sample trees were open grown Douglas-fir 35 to 60 feet tall with full crowns. Adjacent sample trees were separated by at least one chain. Before each application and following the final (third) application, branch and cone samples were collected from all sample trees regardless of their assigned treatment. This allowed intermediate samples to act as a postspray sample for one application and prespray sample for the next.

For each sample period, two 18-inch upper crown branches per tree were collected for population and cone damage. If these 2 branches had fewer than 10 cones, additional branches were cut to provide at least a sample of 10 cones per tree. Cone damage was recorded as follows:

Damage code	Cone condition
M	Dead or mined bud (not expanded)
F	Feeding damage (no larvae present)
L	Number of live budworm larvae per cone
D	Number of dead budworm larvae per cone
OK	No damage or larvae present (expanded)

Mid- to late-season treatment effects were recorded from the following samples:

Sample	Dates
Mature larvae	July 1 and 2
Defoliation	July 24 and 25
Mature cone	August 18

Population densites of mature larvae were taken from two mid-crown branches (18 inches) from each sample tree. Number of larvae and number of new shoots were used to express larval density per 100 shoots. Two additional midcrown branch tips were cut for a defoliation estimate. A total of 25 shoots were rated using the following six-class system:

Defoliation class	Percent defoliation
0	0
1	>0-25
2	26-50
3	51-75
4	76-<100
5	100

Just prior to seed release, mature cone samples were collected to determine cone damage (external), seed yield per cone and seed viability. External cone damage was visually classified and recorded using a rating system developed by Dewey and Jenkins, 1979:

Damage class	Percent damage
1	0
2	>0-10
3	11-25
4	26-50
5	51-75
6	76-100

Following an air drying period, seeds were hand extracted for counting, X-ray analysis, and germination. Seed were pooled by tree and two subsamples taken. One hundred unstratified seeds per tree were X-rayed. Another 100 unstratified seeds were used in a germination test. These seeds were placed 10 per dish on blotter paper saturated with 3 percent solution hydrogen peroxide. Dishes were held at 86° F for 39 days, with 8 hours daily with light and 16 hours without light.

Results

Following the encouraging mortality and foliage protection results with a single application in 1979, we expected similar results with both the double and triple application. Tables 1 and 2 summarize larval mortality and defoliation by tree and treatment. Population reduction at the mid-larval stage and current year foliage protection were all above 90 percent. In both cases, the control means were significantly different than the rest of the treatments, but there were no differences between the double and triple applications.

One technique we used to evaluate the amount of seed and cone damage was the percent of uninfested/undamaged cones. Table 3 displays percent undamaged cones by treatment and sample period. As treatment effects manifest themselves over time, the control means were consistently different from the double and triple application. At the mature cone sample, the double and triple applications were not different. These same differences were found in the visual estimate of external cone damage.

Treatment	Percent external damage
Acephate (2)	2.6a 1/
Acephate (3)	1.4a
Acephate (3R)	1.2a
Carbaryl (2)	0.2a
Carbaryl (2)	0.8a
Carbaryl (3R)	0.3a
Control	34.0b

1/ Means having nonsignificant differences at the 95 percent level based on Duncan's new multiple-range test are followed by the same lower case letter.

The heaviest prespray cone damage occured on the two treatments which were delayed until May 12 (acephate 3R and carbaryl 3R). Again, this pointed out the importance of prespray damage and how just a 3- to 4-day delay can increase prespray damage. For carbaryl (3R) this difference was significant.

A 100-seed subsample extracted from the mature cones was X-rayed to determine the percent sound, hollow and insect-damaged seed. Table 4 summarizes seed condition by treatment. The proportion of sound seed ranged from 59 percent to 67 percent. No significant difference was found among any of the treatments. Seed chalcid damage or the percent hollow seed was also not significant. This indicated that seed condition within the cones was not affected by treatment.

A germination test was conducted to more fully understand treatment effects on seed condition. Germination ranged from 2 percent to 24 percent with the control mean of 6 percent (Table 5). The variations among these data do not indicate a clear pattern of treatment effects. Although some significant difference did occur, it is important to note that the chemical treatments did not seem to interfere with pollination and seed development. One of the triple applications had the highest germination.

Seed production per cone is tabulated by tree and treatment in Table 6. The control mean was significantly different from all the rest but no differences were found between or within the double and triple applications. The triple applications of carbaryl nearly doubled seed production while the best acephate treatment was approximately 35 percent.

Conclusion and Recommendation

The earlier timing of the initial application reduced prespray damage to below 13 percent. The rain effect on the first set of applications is not clear but even though prespray losses were higher for the delayed treatment set (21 and 24 percent), seed production per cone was equal or greater than production for the initial set. The effect of the rain was not significant and not as great as expected. As good application practices logically prescribe, several hours of drying time should follow an application. Seed production increased dramatically with the double and triple application compared to a single application (1979). These data support the usefulness of early double and triple ground applications for protecting current year's foliage and increasing seed and cone yields. Where seed yields are important and budworm populations are moderate to high, a double application of acephate or carbaryl is recommended.

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APPENDIX

Table 1.--Mature larvae per 100 new shoots by tree and treatment from Lubrecht Experimental Forest, 1980.

Tree #	Acephate (2)	Acephate(3)	Acephate (3R)	Carbaryl (2)	Carbaryl (3)	Carbaryl (3R)	Control
1	0	0	0	0	0	0	12.69
2	0	0	0	.75	0	0	10.00
3	0	0	0	0	0	0	21.80
4	0	0	0	.58	0	0	27.73
5	0	.58	0	0	0	0	17.73
6	7.14	.48	0	0	0	0	20.63
7	2.30	0	0	2.74	0	0	21.21
8	0	2.33	0	1.57	0	0	16.39
9	0	0	0	0	0	0	11.45
10	0	0	0	0	0	0	3.57
Mean	.94a	.34a	0a	.56a	0a	0a	16.29b
Percent reduction	94	98	100	97	100	100	

Note: Means having nonsignificant differences at the 95 percent level based on Duncan's new multiple-range test are followed by the same lower case letter.

Table 2.--Percent current defoliation following larval pupation by tree and treatment from Lubrecht Experimental Forest, 1980.

Tree #	Acephate (2)	Acephate (3)	Acephate (3R)	Carbaryl (2)	Carbaryl (3)	Carbaryl (3R)	Control
1	2.25	1.25	1.00	0	1.75	2.00	77.75
2	1.50	0.75	4.25	1.00	1.75	0	88.75
3	13.75	1.75	3.50	.25	0	0	84.00
4	0.25	0	3.25	1.50	.25	0.75	88.75
5	2.00	5.50	24.50	0	2.00	0	71.75
6	5.25	0.25	0.50	0.25	0	0	86.00
7	19.00	0.25	8.75	1.75	0	0.75	64.75
8	3.00	0	0	4.00	0	0	79.75
9	0.25	0.75	10.75	.50	.50	2.00	62.00
10	0.25	0.75	4.25	0.25	0	0	71.00
Mean	4.75a	1.13a	6.08a	0.95a	0.63a	0.55a	77.45b
Percent reduction	94	99	92	99	99	99	

Note: Means having nonsignificant differences at the 95 percent level based on Duncan's new multiple-range test are followed by the same lower case letter.

Table 3.--Percent undamaged cones by treatment and sample period from Lubrecht Experimental Forest, 1980.

Time period	Acephate (2)	Acephate (3)	Acephate (3R)	Carbaryl (2)	Carbaryl (3)	Carbaryl (3R)	Control
Prespray (5 May)	91.6ac	87.8ac	79.4ac	87.3ac	89.6ac	76.1bc	97.6a
Postspray (27 May)	68.1ac	64.8ac	72.7ac	76.5ac	82.6a	66.5ac	50.9bc
Postspray (9 June)	77.7a	77.0a	85.5a	81.7a	87.0a	78.3a	42.1b
Postspray (30 June)	81.4a	80.4a	89.7a	84.0a	76.5a	75.9a	18.4b
Mature cones (18 Aug.)	90.3a	95.2a	94.7a	97.0a	97.5a	95.3a	19.0b

Note: Means having nonsignificant differences at the 95 percent level based on Duncan's new multiple-range test are followed by the same lower case letter.

Table 4.--Summary of seed condition determined by X-ray analysis from Lubrecht Experimental Forest, 1980.

Seed condition	Acephate (2)	Acephate (3)	Acephate (3R)	Carbaryl (2)	Carbaryl (3)	Carbaryl (3R)	Control
Sound	64.0a	66.1a	59.3a	58.2a	62.1a	67.6a	65.5a
Hollow	35.7a	33.6a	40.4a	40.9a	37.8a	32.4a	33.8a
Seed chalcid	0.3a	0.3a	0.3a	0.9a	0.1a	0a	0.7a

Note: Means having nonsignficant differences at the 95 percent level based on Duncan's new multiple-range test are followed by the same lower case letter.

Table 5.--Percent seed germination by tree and treatment from Lubrecht Experimental Forest, 1980.

Tree #	Acephate (2)	Acephate (3)	Acephate (3R)	Carbaryl (2)	Carbaryl (3)	Carbaryl (3R)	Control
1	33	1	0	4	1	0	11
2	6	46	2	0	18	0	0
3	0	7	5	0	14	45	1
4	19	0	8	0	64	0	0
5	0	0	0	60	4	0	9
6	38	0	0	0	22	0	1
7	24	28	6	2	28	0	1
8	7	3	1	0	54	4	14
9	17	0	1	2	7	15	6
10	5	6	0	0	28	4	17
Mean	14.9ac	9.1ac	2.3bc	6.8ac	24.0a	6.8ac	6.0ac

Note: Means having nonsignificant differences at the 95 percent level based on Duncan's new multiple-range test are followed by the same lower case letter.

Table 6.--Total seed per cone by tree and treatment from Lubrecht Experimental Forest, 1980.

Tree #	Acephate (2)	Acephate (3)	Acephate (3R)	Carbaryl (2)	Carbaryl (3)	Carbaryl (3R)	Control
1	36.2	33.7	28.9	41.6	39.4	39.1	34.8
2	48.8	44.2	46.9	53.6	48.4	42.8	28.1
3	41.9	41.5	46.6	52.6	38.2	38.0	19.1
4	36.0	30.9	34.2	37.6	46.6	33.6	43.7
5	42.6	35.0	19.5	32.3	38.7	44.0	11.3
6	38.9	27.7	31.5	43.8	41.7	53.2	14.6
7	29.2	40.3	28.5	31.4	34.8	44.7	25.0
8	13.6	32.6	32.2	39.9	45.2	42.2	12.2
9	37.5	23.9	33.4	34.3	43.6	50.7	22.7
10	14.1	31.8	42.3	21.4	37.1	25.9	13.1
Mean	33.6a	34.2a	34.4a	38.9a	41.4a	41.4a	22.5b

Note: Means having nonsignificant differences at the 95 percent level based on Duncan's new multiple-range test are followed by the same lower case letter.

This report describes project results involving pesticides. It contains recommendations for their use. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife--if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers

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